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Chao et al.

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(54) **GOLF CLUB HEAD**

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(51) **Int. Cl.**
A63B 53/04 (2015.01)

(52) **U.S. Cl.**
CPC ***A63B 53/0466*** (2013.01); *A63B 2053/042* (2013.01); *A63B 2053/045* (2013.01); *A63B 2053/0408* (2013.01); *A63B 2053/0416* (2013.01); *A63B 2053/0425* (2013.01); *A63B 2053/0429* (2013.01); *A63B 2053/0454* (2013.01); *A63B 2053/0458* (2013.01); *A63B 2209/02* (2013.01); *A63B 2209/023* (2013.01)

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USPC 473/324–350, 287–292
See application file for complete search history.

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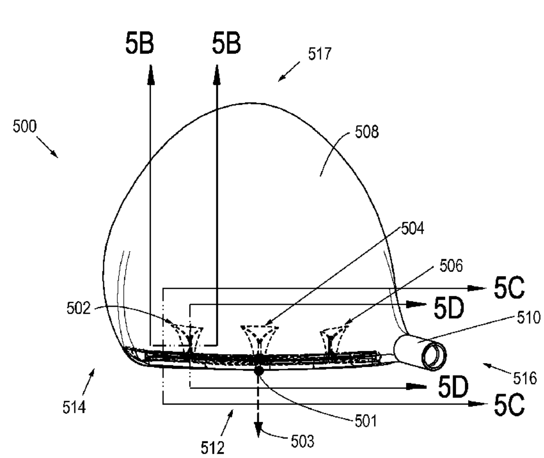
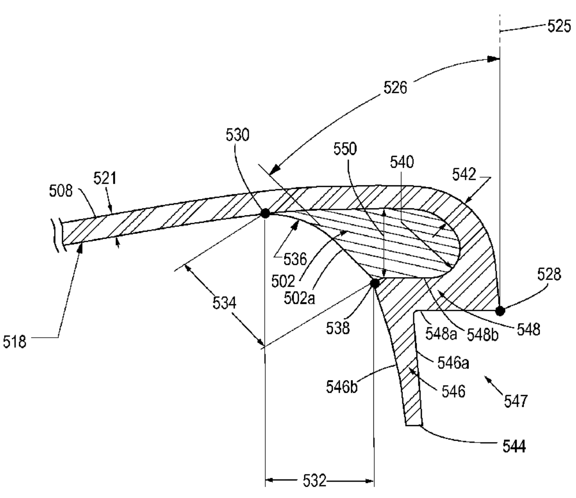
(74) *Attorney, Agent, or Firm* — Klarquist Sparkman, LLP

(57) **ABSTRACT**

A golf club head with a club head body having an external surface with a heel portion, a toe portion, a crown portion, a sole portion, and a front opening is described. A face insert support structure is located at the front opening. The support structure includes a peripheral member and a rear support member. The rear support member has a front surface and a rear surface. A face insert is attached at the front opening and closes the front opening of the body. An undercut fill structure is attached to a portion of the rear surface of the rear support member.

14 Claims, 13 Drawing Sheets





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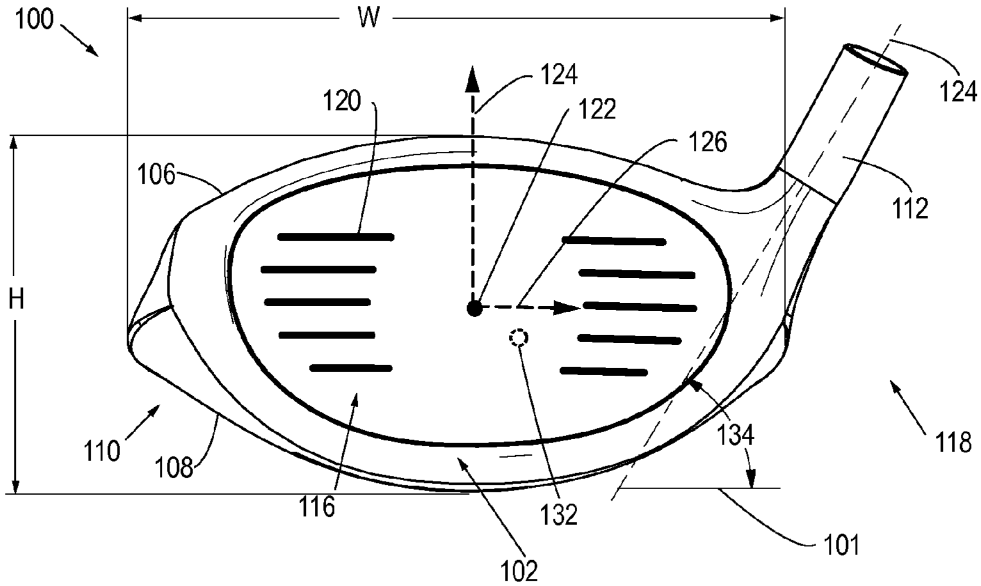
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FIG. 1A

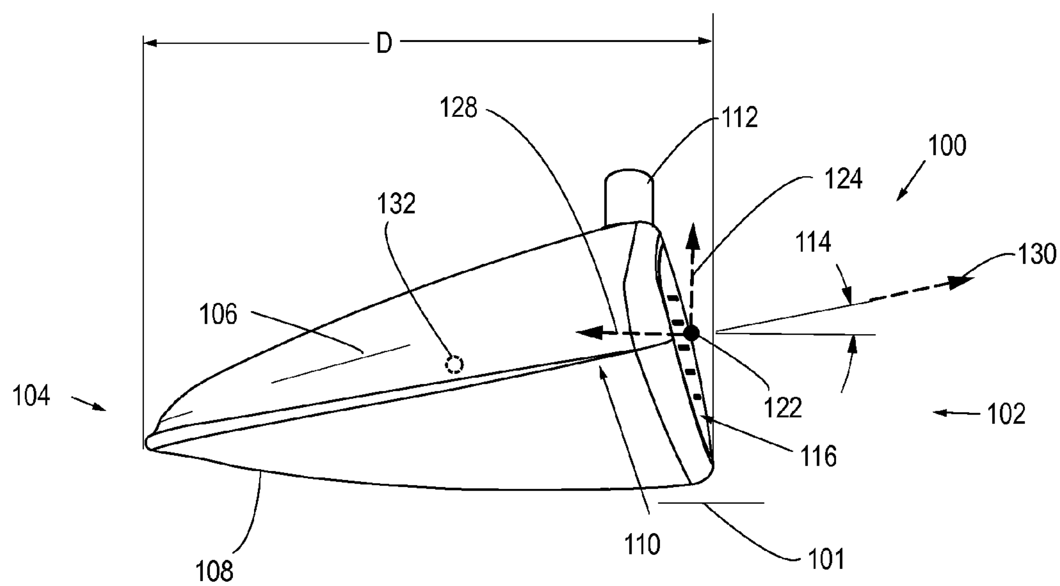
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FIG. 1B

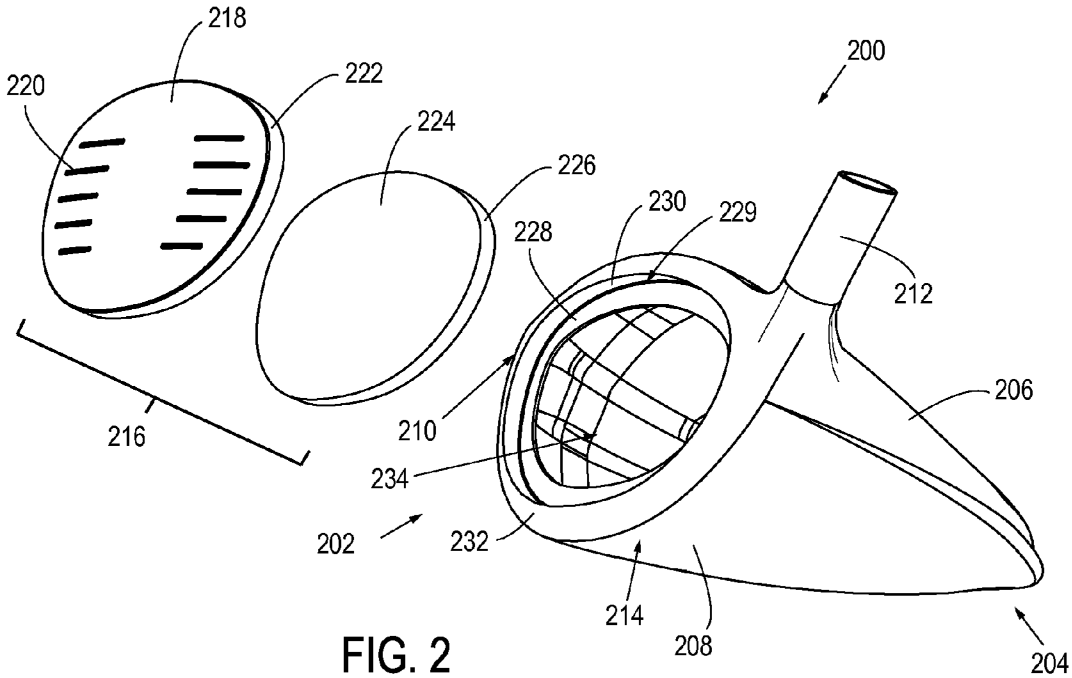
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FIG. 2

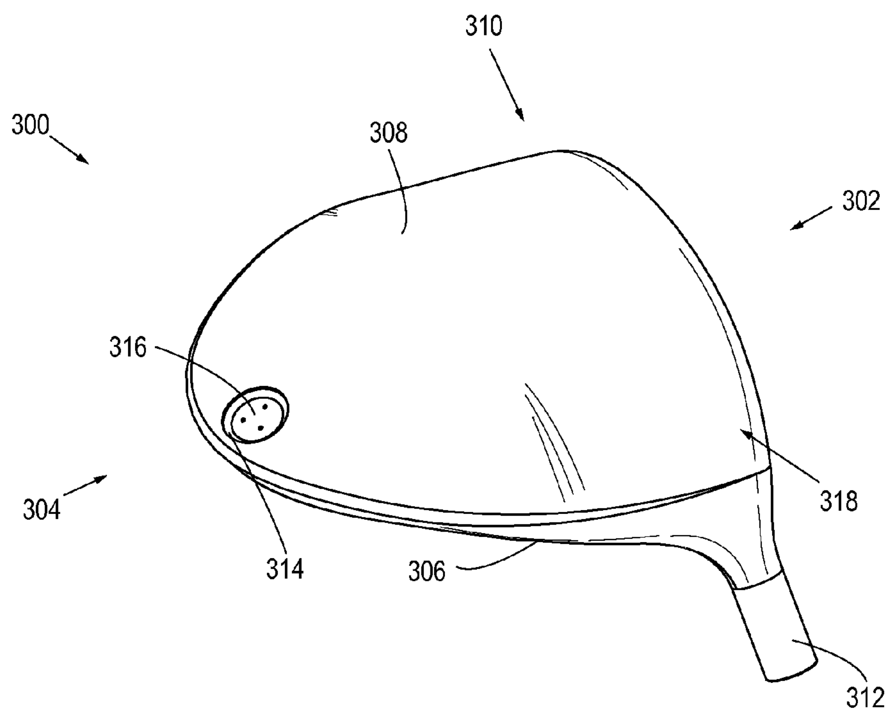
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FIG. 3

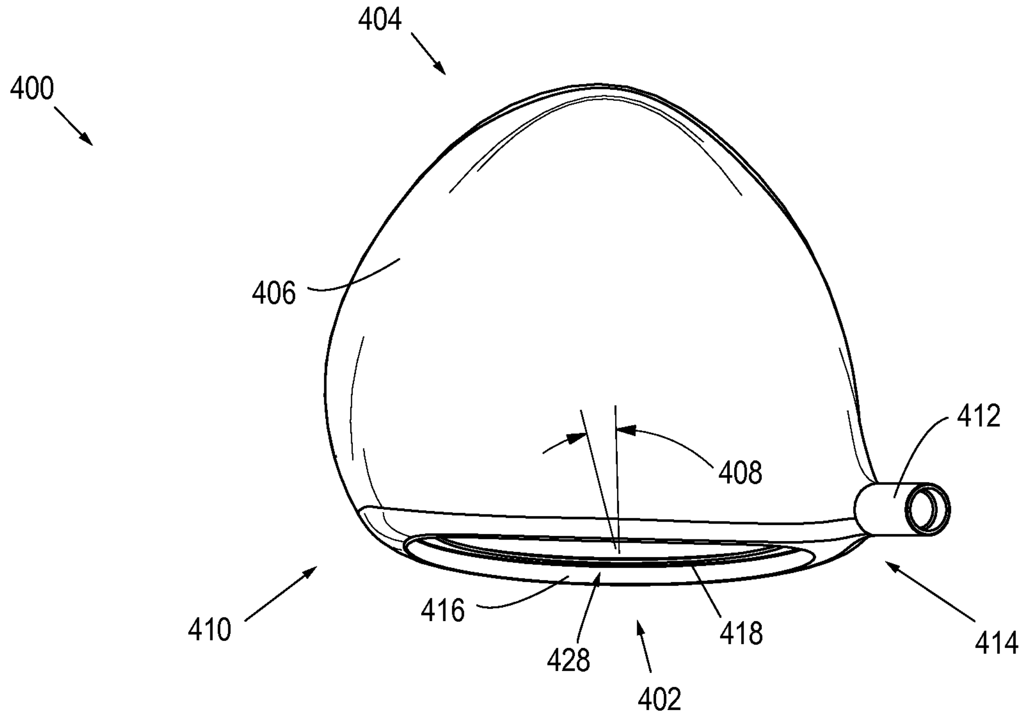
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FIG. 4A

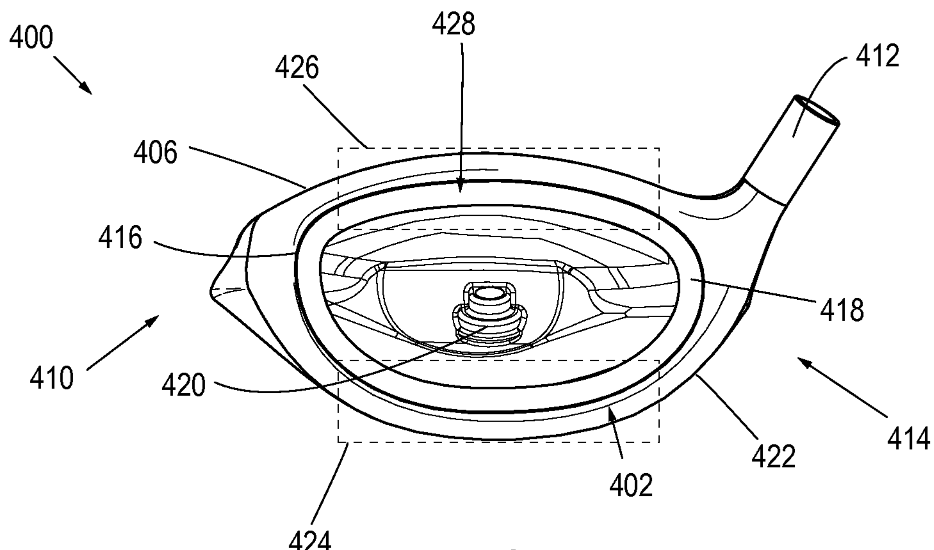
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FIG. 4B

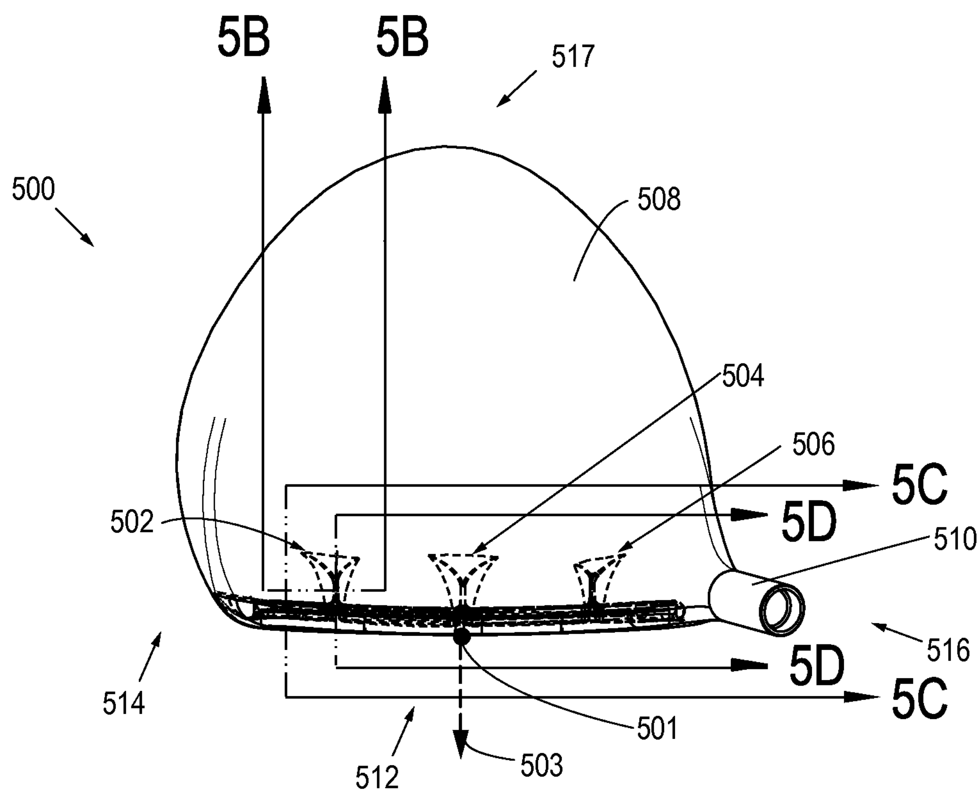

FIG. 5A

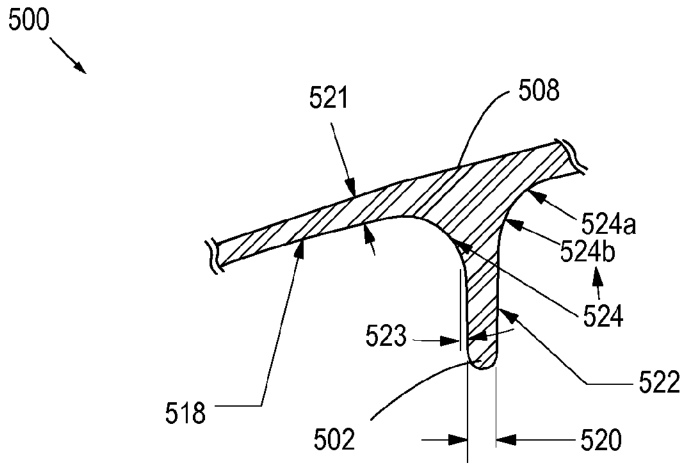
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FIG. 5B

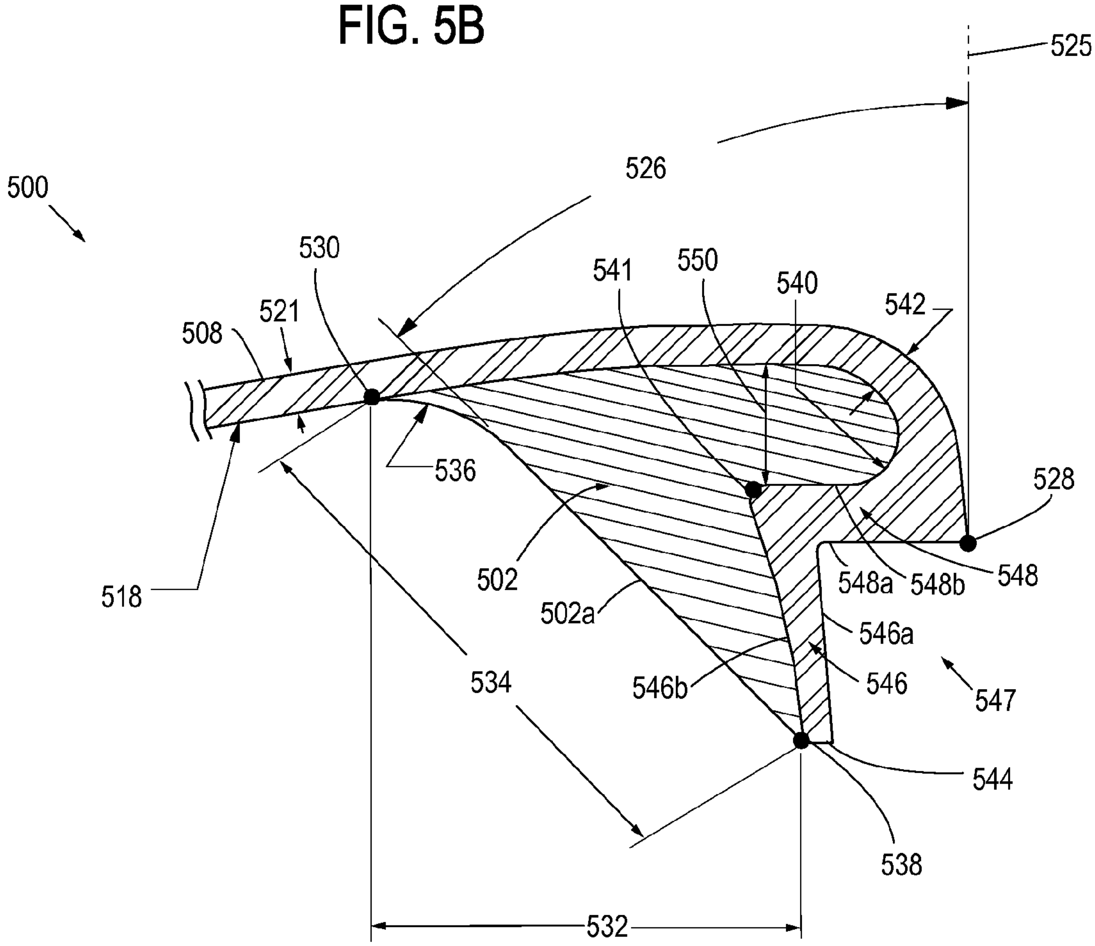
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FIG. 5C

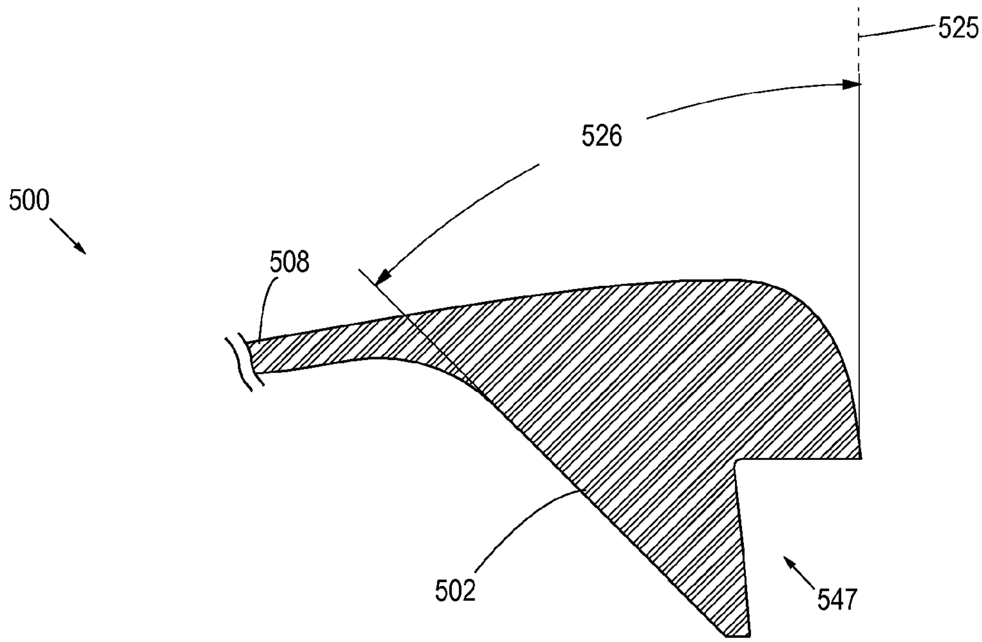
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FIG. 5D

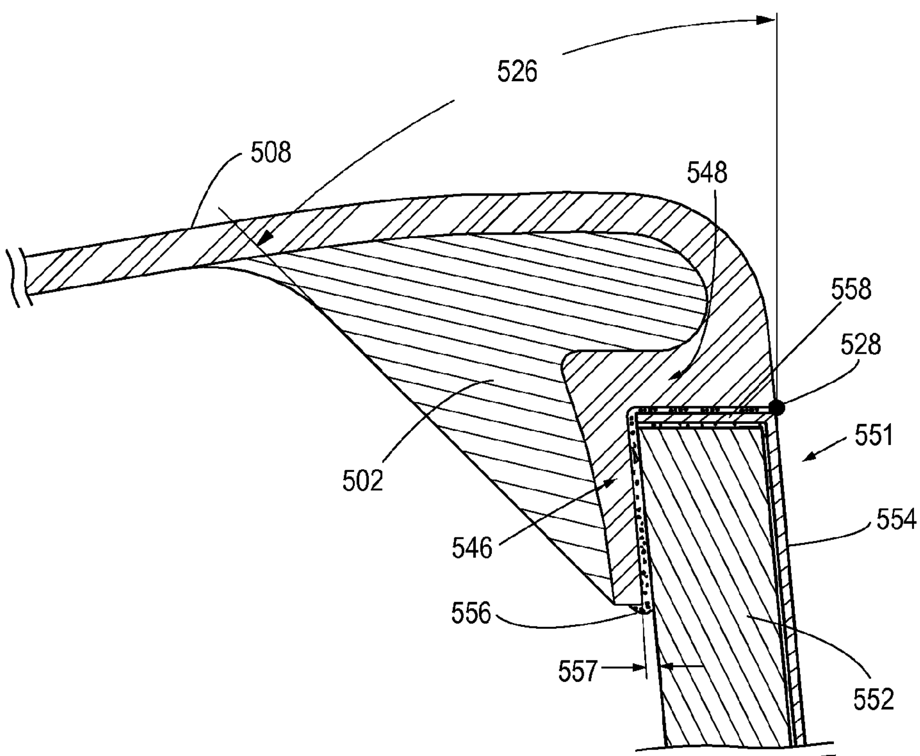
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FIG. 5E

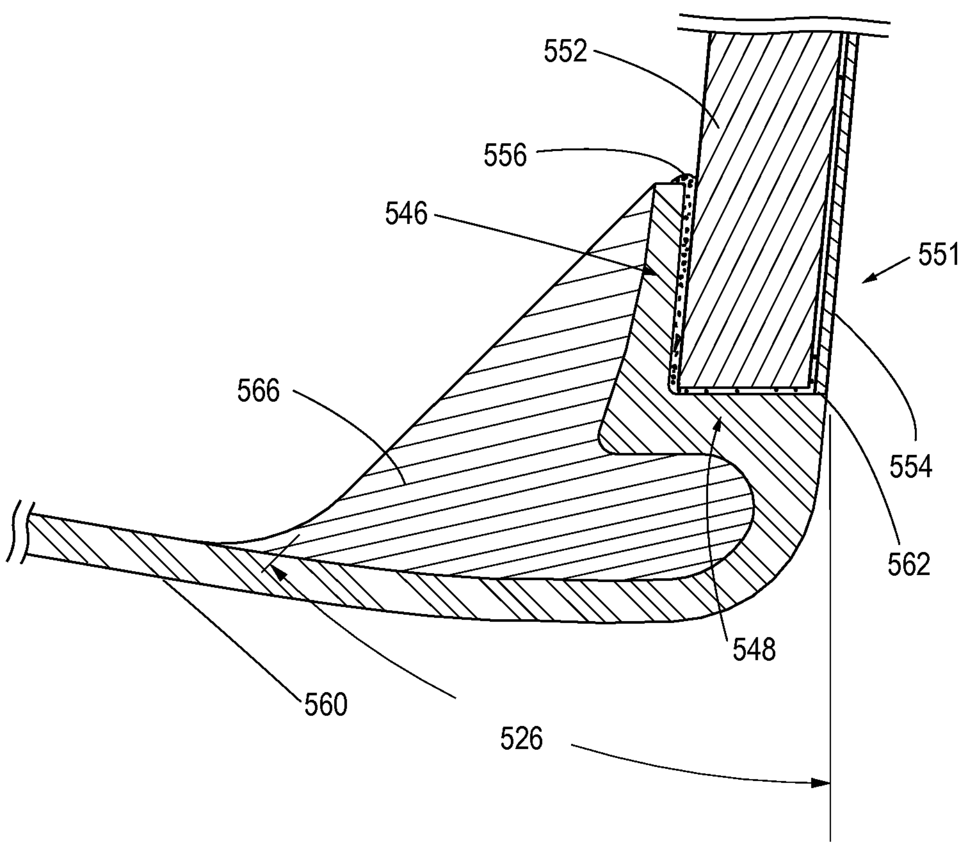

FIG. 5F

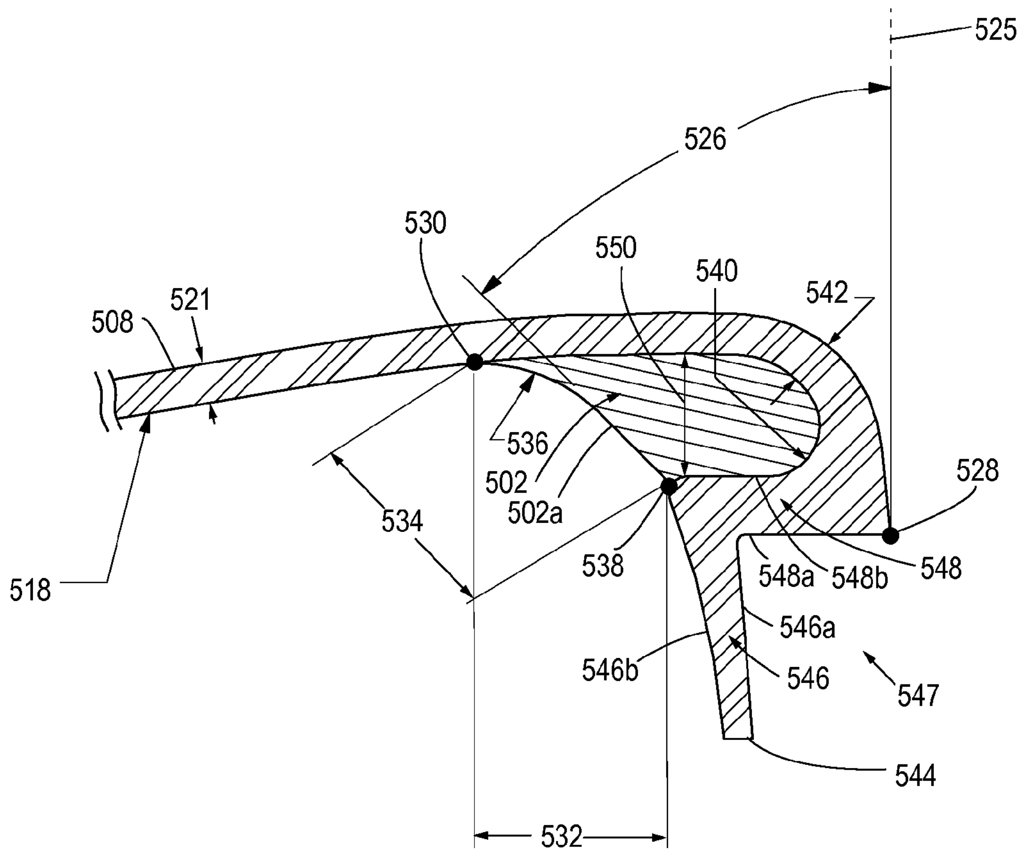
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FIG. 5G

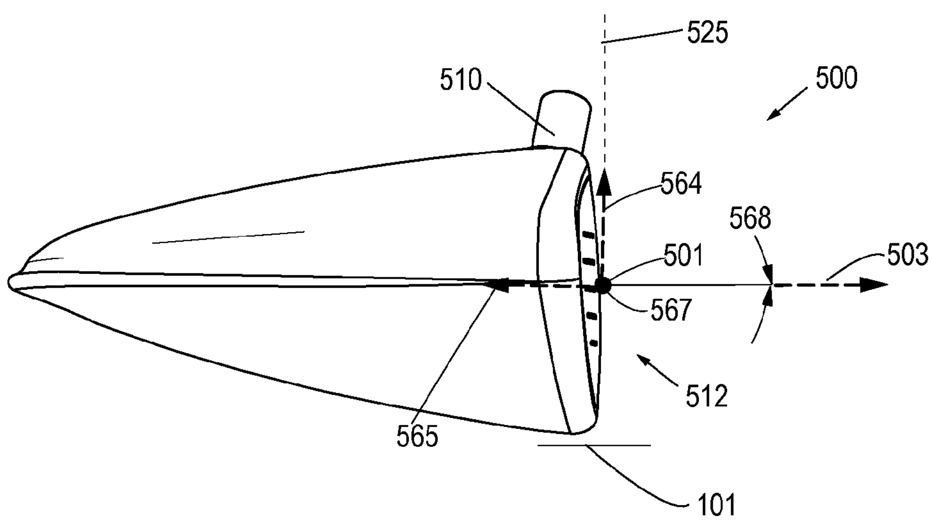
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FIG. 5H

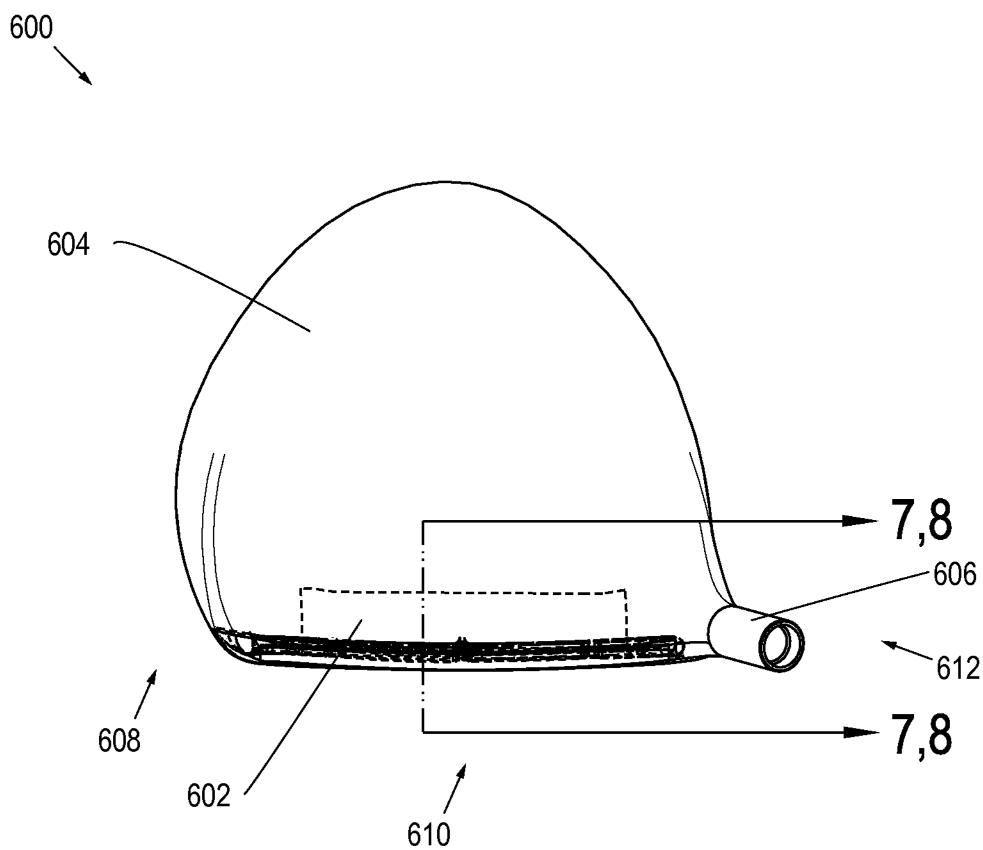

FIG. 6

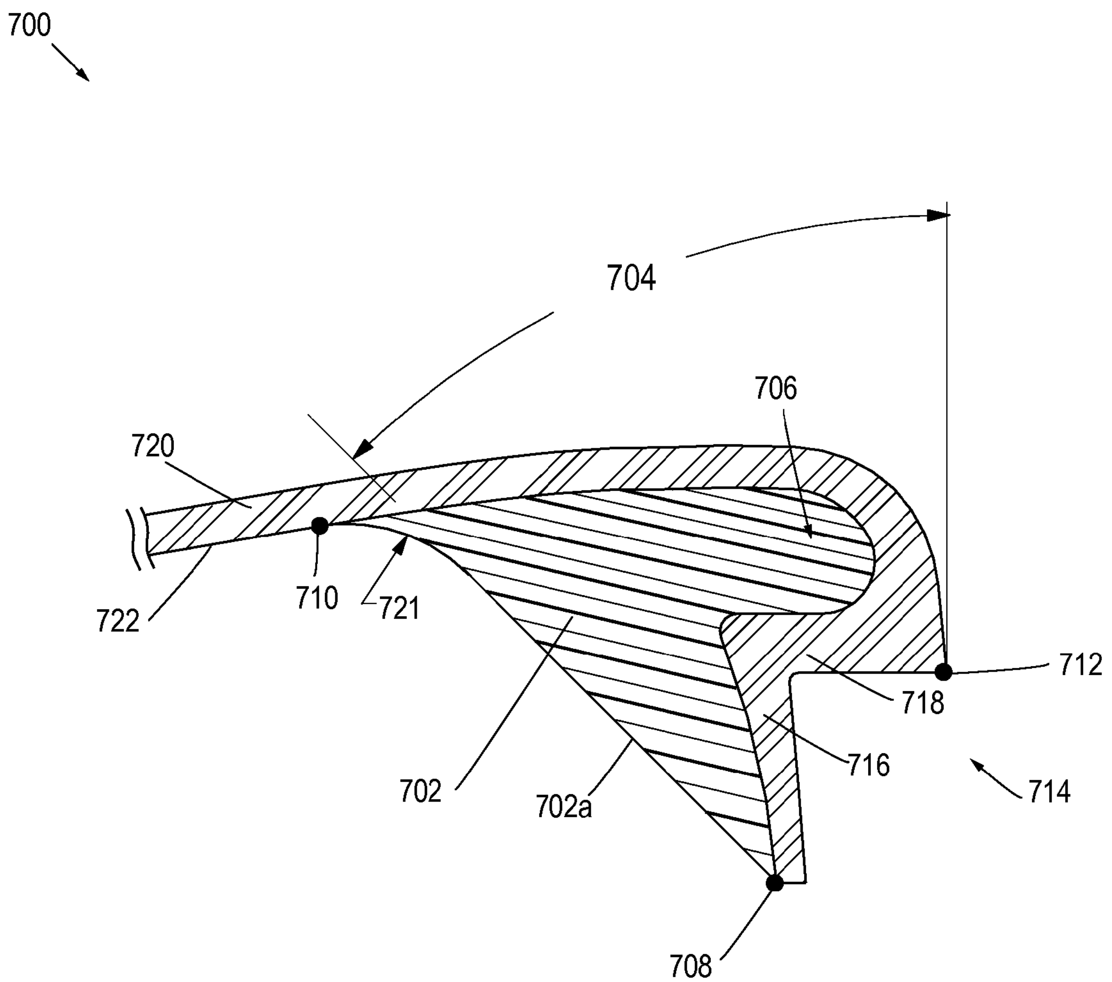

FIG. 7

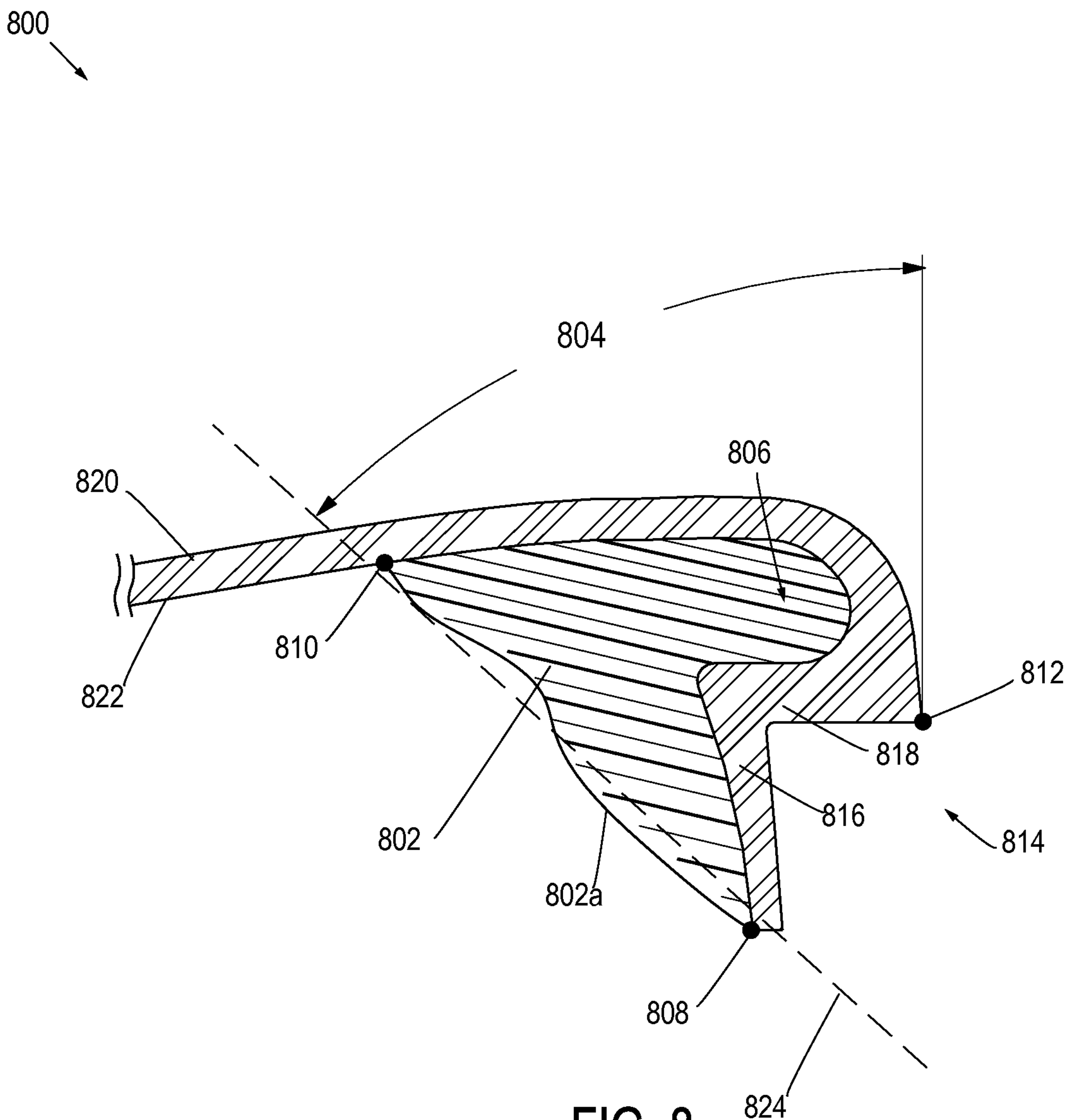

FIG. 8

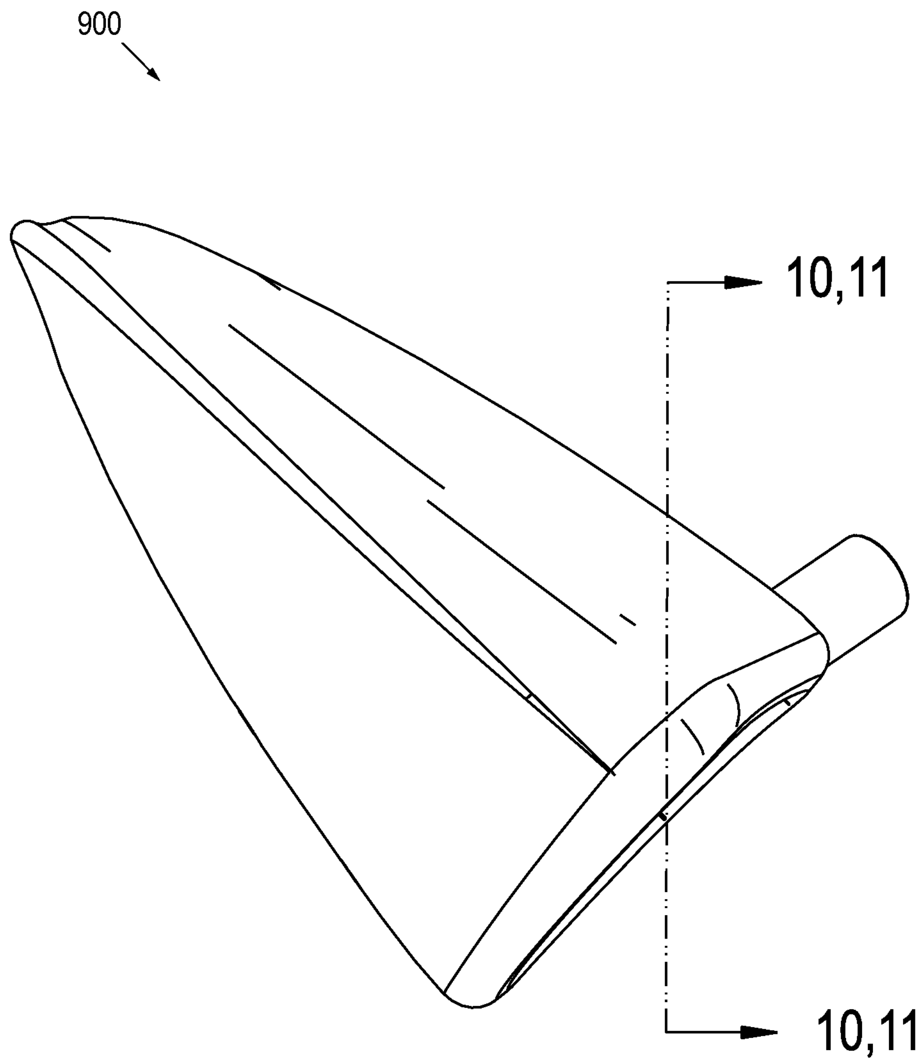

FIG. 9

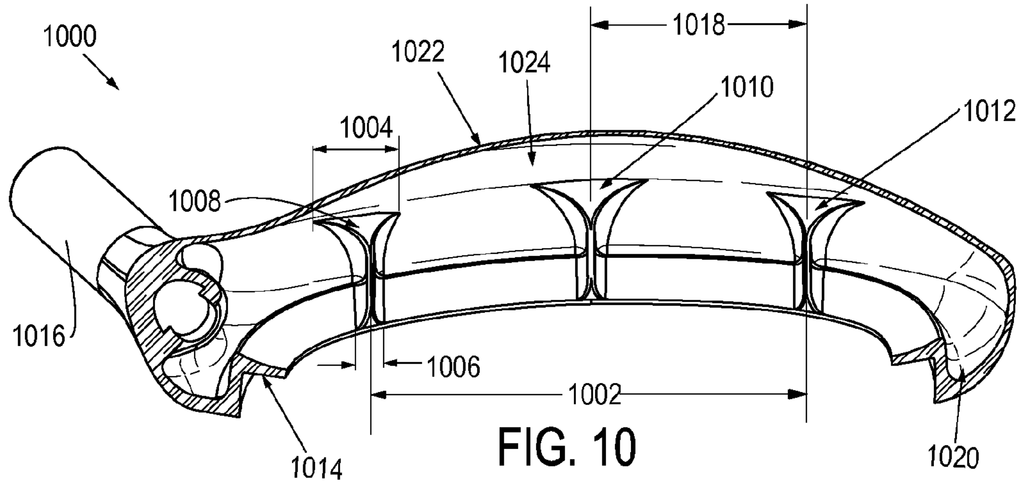
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FIG. 10

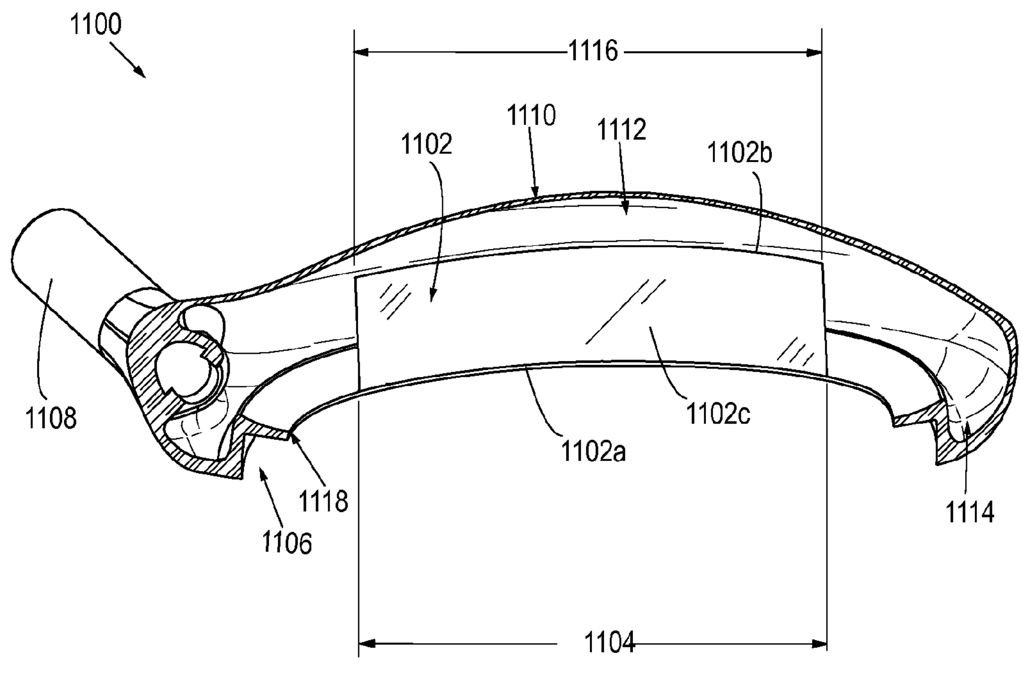
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FIG. 11

GOLF CLUB HEAD

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/898,075, filed May 20, 2013, which is a continuation of U.S. patent application Ser. No. 12/819,652, filed Jun. 21, 2010, which claims priority to and benefit of U.S. Provisional Patent Application No. 61/270,635, filed Jul. 9, 2009, all of which are incorporated herein by reference.

FIELD

The present disclosure relates to a golf club head. More specifically, the present disclosure relates to a front undercut fill structure.

BACKGROUND

Golf is a game in which a player, using many types of clubs, hits a ball into each hole on a golf course in the lowest possible number of strokes. Golf club head manufacturers and designers seek to improve certain performance characteristics such as forgiveness, playability, feel, and sound. In addition, the durability of the golf club head must be maintained while the performance characteristics are enhanced. In general, "forgiveness" is defined as the ability of a golf club head to compensate for mis-hits where the golf club head strikes a golf ball outside of the ideal contact location. Furthermore, "playability" can be defined as the ease in which a golfer can use the golf club head for producing accurate golf shots. Moreover, "feel" is generally defined as the sensation a golfer feels through the golf club upon impact, such as a vibration transferring from the golf club to the golfer's hands. The "sound" of the golf club is also important to monitor because certain impact sound frequencies are undesirable to the golfer.

Golf head forgiveness can be directly measured by the moments of inertia of the golf club head. A moment of inertia is the measure of a golf head's resistance to twisting upon impact with a golf ball. Generally, a high moment of inertia value for a golf club head will translate to a lower amount of twisting in the golf club head during "off-center" hits. Because the amount of twisting in the golf club head is reduced, the likelihood of producing a straight golf shot has increased thereby increasing forgiveness. In addition, a higher moment of inertia can increase the ball speed upon impact thereby producing a longer golf shot.

The United States Golf Association (USGA) regulations constrain golf club head shapes, sizes, and moments of inertia. Due to theses constraints, golf club manufacturers and designers struggle to produce a club having maximum size and moment of inertia characteristics while maintaining all other golf club head characteristics, such as weight and sufficient durability.

SUMMARY

The foregoing and other objects, features, and advantages of the invention will become more apparent from the following detailed description, which proceeds with reference to the accompanying figures.

According to one aspect of the present invention, a golf club head is described having a club head body having an external surface with a heel portion, a toe portion, a crown portion, a sole portion, and a front opening. The golf club

head also includes a face insert support structure located at the front opening. The support structure includes a peripheral member and a rear support member. The rear support member includes a front surface and a rear surface. A face insert is attached at the front opening and closes the front opening of the body. At least one undercut fill structure attached to a portion of the rear surface of the rear support member is described.

In one example, the face insert includes at least a portion comprising prepreg plies having a fiber areal weight.

In another example, the golf club head includes a metallic cap attached to the prepreg plies and the prepreg plies are configured to reinforce a majority of a metallic cap striking surface. The metallic cap abuts the transition edge to form a substantially flush golf club head front surface.

In yet another example, the thickness of the prepreg plies is about 4.5 mm or less, and the thickness of the metallic cap is about 0.5 mm or less. The golf club head has a coefficient of restitution of at least 0.79 and a characteristic time of less than at least 257 μs.

In one example, the metallic cap is formed of a material with a density less than 5 g/cc. The cap covers a front surface of the prepreg plies and includes a peripheral rim.

In another example, the face insert's total thickness is within a range of about 1 mm to about 8 mm.

In yet another example, the prepreg plies include carbon fiber reinforcement having a fiber areal weight of at least 100 g/m^2. The face insert's total thickness is within a range of about 2.5 mm to about 4.5 mm.

In one example, the prepreg plies have a fiber areal weight of less than 100 g/m2.

In another example, the thickness of the face insert is non-constant.

In yet another example, the metallic cap is comprised of a titanium alloy.

In one example, the peripheral member extends around a periphery of the front opening, and the face insert is coupled to the peripheral member.

In another example, the at least one undercut fill structure substantially attaches to a tip portion of the rear support member.

In yet another example, the at least one undercut fill structure forms a return angle of about 45 degrees or more with a vertical X-Z plane.

In one example, a front region of the crown is at least about 1 mm thick in a location where the at least one undercut fill structure attaches to an interior surface of the crown.

In another example, a front region of the sole is at least about 1 mm thick in a location where the at least one undercut fill structure attaches to an interior surface of the sole.

In yet another embodiment, the at least one undercut fill structure includes at least two ribs. The at least one undercut fill structure can include at least three ribs equidistantly spaced from each other.

In one example, the at least one undercut fill structure adds less than about 5 grams of additional weight to a total club head weight.

In another example, the at least one undercut fill structure adds less than about 10 grams of total additional weight to a total club head weight.

In another example, the at least one undercut fill structure includes a transition radius of about 1 mm to about 10 mm between the undercut fill structure and at least one of the crown portion and the sole portion.

According to one aspect of the present invention, a club head body having an external surface with a heel portion, a toe portion, a crown portion, a sole portion, and a front opening is described. The club head further includes a face insert support structure located at the front opening. The support structure includes a peripheral member and a rear support member. The rear support member includes a front surface and a rear surface. The face insert is attached at the front opening and closes the front opening of the body. At least one undercut fill structure is attached to a portion of the rear surface of the rear support member. A portion of the at least one undercut fill structure is located in an undercut between the face insert support structure and the crown portion.

According to another aspect of the present invention at least one undercut fill structure is attached to a portion of the rear surface of the rear support member and a portion of the at least one undercut fill structure is located in an undercut between the face insert support structure and the sole portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is an elevated front view of a golf club head showing a golf club head origin coordinate system and a center of gravity according to one embodiment.

FIG. **1**B is an elevated side view of the golf club head in FIG. **1**A.

FIG. **2** is an exploded assembly view of a golf club head.

FIG. **3** is an isometric sole view of a golf club head.

FIG. **4**A is a top view of a golf club head with a face insert removed.

FIG. **4**B is a front view of the golf club head in FIG. **4**A.

FIG. **5**A is a top view of a golf club head.

FIG. **5**B is a cross-sectional view of a undercut fill structure taken along section lines **5**B-**5**B in FIG. **5**A.

FIG. **5**C is a cross-sectional view of the undercut fill structure taken along section lines **5**C-**5**C in FIG. **5**A.

FIG. **5**D is a cross-sectional view of the undercut fill structure taken along section lines **5**D-**5**D in FIG. **5**A.

FIG. **5**E is a cross-sectional view of an undercut fill structure and face insert according to another embodiment.

FIG. **5**F is a cross-sectional view of an undercut fill structure and face insert according to another embodiment.

FIG. **5**G is a cross-sectional view of an undercut fill structure according to another embodiment.

FIG. **5**H is an elevated side view of a golf club head.

FIG. **6** is a top view of a golf club head.

FIG. **7** is a cross-sectional view of an undercut fill structure, according to another embodiment, taken along section lines **7-7** in FIG. **6**.

FIG. **8** is a cross-sectional view of an undercut fill structure, according to another embodiment, taken along section lines **8-8** in FIG. **6**.

FIG. **9** is a rotated side view of a golf club head.

FIG. **10** is a cross-sectional view of undercut fill structures, according to another embodiment, taken along section lines **10-10** in FIG. **9**.

FIG. **11** is a cross-sectional view of an undercut fill structure, according to another embodiment, taken along section lines **11-11** in FIG. **9**.

DETAILED DESCRIPTION

Various embodiments and aspects of the inventions will be described with reference to details discussed below, and the accompanying drawings will illustrate the various embodiments. The following description and drawings are illustrative of the invention and are not to be construed as limiting the invention. Numerous specific details are described to provide a thorough understanding of various embodiments of the present invention. However, in certain instances, well-known or conventional details are not described in order to provide a concise discussion of embodiments of the present inventions.

Embodiments of a golf club head providing a face insert support structure and undercut fill structures are described herein. In some embodiments, the golf club head has a desired shape for providing maximum golf shot forgiveness given a maximum head volume, a maximum head face area, and a maximum head depth according to desired values of these parameters, and allowing for other considerations such as the physical attachment of the golf club head to a golf club and golf club aesthetics.

In the embodiments described herein, the “face size” or “striking surface area” is defined according to a specific procedure described herein. A front wall extended surface is first defined which is the external face surface that is extended outward (extrapolated) using the average bulge radius (heel-to-toe) and average roll radius (crown-to-sole). The bulge radius is calculated using five equidistant points of measurement fitted across a 2.5 inch segment along the x-axis (symmetric about the center point). The roll radius is calculated by three equidistant points fitted across a 1.5 inch segment along the y-axis (also symmetric about the center point).

The front wall extended surface is then offset by a distance of 0.5 mm towards the center of the head in a direction along an axis that is parallel to the face surface normal vector at the center of the face. The center of the face is defined according to USGA “Procedure for Measuring the Flexibility of a Golf Clubhead”, Revision 2.0, Mar. 25, 2005.

A face front wall profile shape curve (herein, “S_f”) is defined as the intersection of the external surface of the head with the offset extended front wall surface. Furthermore, the hosel region of the face front wall profile shape curve is trimmed by finding the intersection point (herein, “P_a”) of S_f with a 30 mm diameter cylindrical surface that is co-axial with the shaft (or hosel) axis. A line is drawn from the intersection point, P_a, in a direction normal to the hosel/shaft axis which intersects the curve S_f at a second point (herein, “P_b”). The two points, P_a and P_b, define two trimmed points of S_f. The line drawn from P_a to P_b defines the edge of the “face size” as defined in the present application.

Therefore, the “face size” is a projected area normal to a front wall plane which is tangent to the face surface at the geometric center of the face excluding the hosel portion as described above. In certain embodiments described herein, the face size is at least 5,000 mm^2.

FIGS. **1**A and **1**B show a wood-type (e.g., driver or fairway wood) golf club head **100** including a hollow body having a crown portion **106**, a sole portion **108**, a front portion **102**, and a back portion **104**. The club head **100** also includes a hosel **112** which defines a hosel bore and is connected with the hollow body. The hollow body further includes a heel portion **118** and a toe portion **110**. A striking surface **116** is located on the front portion **102** of the golf club head **100** having score lines or markings **120**. In some embodiments, the striking surface **116** can include a bulge and roll curvature or a face plate insert. The striking surface **116** has a face normal vector **130** that forms a face loft angle **114**.

In some embodiments of the present invention, the striking surface **116** is at least partially made of a composite material as described in U.S. patent application Ser. No. 10/442,348 (now U.S. Pat. No. 7,267,620), Ser. No. 10/831,496 (now U.S. Pat. No. 7,140,974), Ser. No. 11/642,310, Ser. No. 11/825,138, Ser. No. 11/998,436, Ser. No. 11/895,195, Ser. No. 11/823,638, Ser. No. 12/004,386, Ser. No. 12/004,387, Ser. No. 11/960,609, Ser. No. 11/960,610, and Ser. No. 12/156,947, which are incorporated herein by reference. The composite material can be manufactured according to the methods described at least in U.S. patent application Ser. No. 11/825,138.

In other embodiments, the striking surface **116** is at least partially made from a metal alloy (e.g., titanium, steel, aluminum, and/or magnesium), ceramic material, or a combination of composite, polymer, metal alloy, and/or ceramic materials. Moreover, the striking face **116** can be a striking plate having a variable thickness as described in U.S. Pat. Nos. 6,997,820, 6,800,038, 6,824,475, and 7,066,832 which are incorporated herein by reference.

FIGS. **1**A and **1**B generally show a club head origin coordinate system being provided such that the location of various features of the club head (including, e.g., a club head CG) can be determined. In FIGS. **1**A and **1**B, a club head origin point **122** is represented on the club head **100**. The club head origin point **122** is positioned at the ideal impact location which can be a geometric center of the striking surface **116**.

The head origin coordinate system is defined with respect to the head origin point **122** and includes a Z-axis **124**, an X-axis **126**, and a Y-axis **128**. The Z-axis **124** extends through the head origin point **128** in a generally vertical direction relative the ground **101** when the club head **100** is at an address position (although the Z-axis **124**, X-axis **126**, and Y-axis **128** are independent of club head **100** orientation). Furthermore, the Z-axis **124** extends in a positive direction from the origin point **122** in an upward direction.

The X-axis **126** extends through the head origin point **122** in a toe-to-heel direction substantially parallel or tangential to the striking surface **116** at the origin point **122**. The X-axis **126** extends in a positive direction from the origin point **122** to the heel **118** of the club head **100** and is perpendicular to the Z-axis **124** and Y-axis **128**.

The Y-axis **128** extends through the head origin point **122** in a front-to-back direction and is generally perpendicular to the X-axis **126** and Z-axis **124**. The Y-axis **128** extends in a positive direction from the origin point **122** towards the rear portion or back portion **104** of the club head **100**.

Referring to FIGS. **1**A and **1**B, the golf club heads described herein each have a maximum club head height (H, top-bottom), width (W, heel-toe) and depth (D, front-back). The maximum height, H, is defined as the distance between the lowest and highest points on the outer surface of the golf club head body measured along an axis parallel to the origin Z-axis **124** when the club head is at a proper address position. The maximum depth, D, is defined as the distance between the forward-most and rearward-most points on the surface of the body measured along an axis parallel to the origin Y-axis **128** when the head is at a proper address position. The maximum width, W, is defined as the distance between the farthest distal toe point and closest proximal heel point on the surface of the body measured along an axis parallel to the origin X-axis **126** when the head is at a proper address position. FIG. **1**A further shows a lie angle **134** between a hosel axis **124** and a level ground surface **101** when the head **100** is at a proper address position.

The height, H, width, W, and depth, D, of the club head in the embodiments herein are measured according to the United States Golf Association "Procedure for Measuring the Club Head Size of Wood Clubs" revision 1.0 and Rules of Golf, Appendix II(4)(b)(i).

Golf club head moments of inertia are defined about three axes extending through the golf club head CG **132** including: a CG z-axis extending through the CG **132** in a generally vertical direction relative to the ground **101** when the club head **100** is at address position, a CG x-axis extending through the CG **132** in a heel-to-toe direction generally parallel to the origin X-axis **126** and generally perpendicular to the CG z-axis, and a CG y-axis extending through the CG **132** in a front-to-back direction and generally perpendicular to the CG x-axis and the CG z-axis. The CG x-axis and the CG y-axis both extend in a generally horizontal direction relative to the ground **101** when the club head **100** is at the address position. In other words, the CG x-axis and CG y-axis lie in a plane parallel to the ground **101**. Specific CG location values are discussed in further detail below with respect to certain exemplary embodiments.

The moment of inertia about the golf club head CG x-axis is calculated by the following equation:

$$I_{CG_x}=\int(y^2+z^2)dm \quad \text{Eq. 1}$$

In the above equation, y is the distance from a golf club head CG xz-plane to an infinitesimal mass, dm, and z is the distance from a golf club head CG xy-plane to the infinitesimal mass, dm. The golf club head CG xz-plane is a plane defined by the CG x-axis and the CG z-axis. The CG xy-plane is a plane defined by the CG x-axis and the CG y-axis.

Moreover, a moment of inertia about the golf club head CG z-axis is calculated by the following equation:

$$I_{CG_z}=\int(x^2+y^2)dm \quad \text{Eq. 2}$$

In the equation above, x is the distance from a golf club head CG yz-plane to an infinitesimal mass dm and y is the distance from the golf club head CG xz-plane to the infinitesimal mass dm. The golf club head CG yz-plane is a plane defined by the CG y-axis and the CG z-axis. Specific moment of inertia values for certain exemplary embodiments are discussed further below.

FIG. **2** illustrates a golf club head **200** including a front portion **202**, a rear portion **204**, a toe portion **210**, a heel portion **214**, a crown portion **206**, a sole portion **208**, a hosel **212**, and a face insert **216**. The front portion **202** includes a front opening **234** having a face insert support structure **229** that includes a peripheral member **230** and a rear support member **228**. The face insert **216** is attached at the front opening **234** and thereby closes the front opening of the body when the club head is fully assembled. The peripheral member **230** extends from a front face surface **232** toward the rear portion **204** of the club. The rear support member **228** is connected to an end of the peripheral member **230** and tapers inwardly toward a center of the front opening **234**. In one embodiment, the specific dimensions of the insert support structure **229** are similar to those described in U.S. Pat. No. 7,140,974, which has been incorporated by reference.

In certain embodiments, the face insert **216** is adhesively or mechanically attached to the face insert support structure **229**. In one embodiment, an epoxy adhesive such as 3M™ Scotch-Weld™ Epoxy Adhesive DP460 is utilized having a shore D hardness of about 75 to 84. It is understood that numerous equivalent adhesives can be used to attach the face insert **216** to the support structure **229**.

In one embodiment, the face insert **216** includes a composite layer **224** having a side wall **226** portion. A cover layer **218** having a side wall portion **222** is attached to the composite layer **224** and can include score lines **220**. In one embodiment, the cover layer **218** can be a polymer cover layer that attaches to the front surface of the composite layer **224**. In another embodiment, the cover layer **218** can be a metallic titanium such as 6-4 titanium, 10-2-3 titanium, 15-3-3-3 titanium, 7-2 titanium, or commercially pure titanium. In certain embodiments, the wall portion **222** of the cover layer **218** is excluded and therefore the cover layer **218** does not overlap with the side wall **226** of the composite layer **224**. In other embodiments, the cover layer **218** acts as a metallic cap where the wall portion **222** of the cover layer **218** does overlap with the side wall **226** of the composite layer **224**.

FIG. **3** shows a sole view of an exemplary embodiment club head **300** including a front portion **302**, a rear portion **304**, a heel portion **318**, a toe portion **310**, a crown portion **306**, and a sole portion **308**. A movable weight **316** is located within a weight portion **314** in the rear portion **304** of the sole **308**. The movable weight **316** increases the MOI of the club head while lowering the CG location.

FIG. **4**A illustrates a top view of a club head **400** with a face insert removed. The club head **400** includes a front portion **402**, a rear portion **404**, a heel portion **414**, a toe portion **410**, and a crown portion **406**. The club head **400** also includes a face angle **408** when at an address position. A face insert support structure **428** including a peripheral member **416** and rear support member **418** are also shown.

FIG. **4**B shows a front view of the club head **400** with the face insert removed. An internal surface area of the club head is shown including a weight port **420** located in a rear sole **422** region. FIG. **4**B further shows an upper zone **426** on the striking face near the crown portion **406** and a lower zone **424** located on the striking face near the sole region **422**. The upper zone **426** includes an upper portion of the insert support structure **428** adjacent or immediately next to the crown portion **406**. The lower zone **424** includes a lower portion of the insert support structure adjacent or immediately next to the sole **422**.

FIG. **5**A shows a club head **500** including a heel portion **516**, toe portion **514**, front portion **512**, a hosel **510**, and a rear portion **517**. The club head **500** contains a club head origin point **501** and origin X-Y-Z axes previously described. The club head **500** is not oriented in the address position. Instead of an address position, the club head is oriented in a de-lofted (no loft) position where the loft angle is about zero and the club head origin point **501** on the face of the club head is a tangent point with respect to an X-Z plane. In other words, a face normal vector **503** is parallel with an origin point y-axis that is parallel with a flat ground surface **101**.

FIG. **5**H illustrates a club head **500** in a de-lofted orientation with an origin Z-axis **564**, origin Y-axis **565**, and origin X-axis **567** (pointing into the page and perpendicular to the Y-axis **565** and Z-axis **564**). The club head **500** includes an origin point **501**, a loft angle **568** of about zero, a front portion **512**, a face normal vector **503**, and an X-Z plane **525** which is further discussed in detail below. In the de-lofted position, the face normal vector **503**, X-axis **567**, and Y-axis **565** are parallel with a flat ground plane **101**.

With respect to FIG. **5**A, in one exemplary embodiment, the club head **500** further includes three undercut fill structures **502**,**504**,**506** in an upper zone similar to the upper zone described in FIG. **4**B. It is understood that any number of multiple undercut fill structures can be provided. A first undercut fill structure **502** is located near a toe-side portion of the club head **500**. A third undercut fill structure **506** is locate near a heel-side portion of the club head **500** and a second undercut fill structure **504** is located in-between the first **502** and third **506** undercut fill structures in a central region of the upper zone.

FIG. **5**B illustrates a cross-sectional view of club head **500** taken along cross-sectional lines **5**B-**5**B (parallel with the origin X-Z plane) in FIG. **5**A. Specifically, a cross-sectional view of the first undercut fill structure **502** or rib is shown having a radius transition region **524** between the first undercut fill structure **502** and an interior crown surface **518** in a plane parallel with the origin X-Z plane. In certain embodiments, the transition region **524** can have a radius of about 1 mm to 10 mm. In one embodiment, the transition region includes a first transition radius **524***a* of at least about 5 mm near the interior crown surface **518** and a second transition **524***b* blending radius of at least about 1.5 mm near the surface of the first undercut fill structure **502** wall **522**. The radius in the transition region **524** is critical in reducing the amount of stress concentration created in the attachment between the undercut fill structure wall **522** and the interior crown surface **518**. In certain embodiments, the first transition or blending radius **524***a* is greater than about 5 mm near the interior crown surface **518**.

In one embodiment, the undercut fill structure wall **522** includes at least a one degree draft angle **523** or taper for ease of manufacturing, such as simplifying the ability to release a part from a mold. In one embodiment, the undercut fill structures **502**,**504**,**506** taper to an end thickness **520** of about 1 mm. In certain embodiments, the undercut fill structures are cast or molded ribs that are comprised of the same material as the club head **500**, such as a titanium alloy. In other embodiments, the undercut fill structure is made of a material different from the club head **500** material.

FIG. **5**B further shows a crown thickness **521** immediately adjacent or near the transition region **524** or attachment zone of the undercut fill structures. In one embodiment, the crown thickness **521** is at least about 1 mm to provide adequate support to the undercut fill structures **502**,**504**,**506**. Forces created upon impact on the striking plate can transfer through the undercut fill structures to cause failure or cracking in a region where the undercut fill structures attach to the crown **508** or sole. Thus, a crown thickness **521** of at least about 1 mm in a region where the undercut fill structure **502** attaches to the crown **518** is preferred. In certain embodiments, the remaining body thicknesses in the remaining crown (outside of a rib attachment region), sole, heel, and toe regions are less than about 0.8 mm to maintain a desirably low CG location.

FIG. **5**C illustrates a cross-sectional view of club head **500** taken along cross-sectional lines **5**C-**5**C (parallel with the origin Y-Z plane) in FIG. **5**A. A face insert support structure **547** including a rear support member **546** and peripheral member **548** is shown. The rear support member **546** includes a front surface **546***a* and a rear surface **546***b*. The peripheral member **548** also includes a front surface **548***a* and a rear surface **548***b*. An undercut or recess **540** separates the face insert support structure **547** from the crown portion **508**. In certain embodiments, the undercut **540** is primarily defined by an undercut **540** radius that is about 1 mm to about 2 mm, or about 1.5 mm. In one embodiment, the undercut **540** radius is between about 3 mm and 4 mm, or about 3.3 mm or 3.4 mm. The crown **508** includes the interior crown surface **518** having a certain thickness **521** as previously described. The undercut or recess **540** can have a depth of about 4.0 mm to about 5.5 mm with respect to a corner location **541** along the origin y-axis. The length of the rear support member **546** as measured from the peripheral member **548** front surface **548***a* is between about 4 mm and 10 mm, preferably about 6 mm. The thickness of the rear support member **546** can have an initial thickness of about 2 mm to 3 mm and taper to the tip **544** with a thickness of about 0.8 mm to about 1.8 mm, preferably about 0.85 mm.

The rib **502** is shown connecting the face insert support structure **547** and a portion of the crown **508**. In one embodiment, the rib **502** fills the undercut **540** and extends between two contact points. A first contact point **538** of the rib **502** is located near a rear support member end or tip **544**. In another embodiment, the first contact point **538** can be slightly spaced away from the tip **544** without departing from the scope of this invention. The rib **502** extends from the first contact point **538** to a second contact point **530** located on the crown interior surface **518**. In order to provide adequate durability, the rib **502** should contact at least a portion of the rear support member rear surface **546***b*.

In certain embodiments, the rib length **534** between the first contact point **538** and second contact point **530** is about 10 mm to 15 mm. In one embodiment, the rib length **534** is about 12 mm to about 14 mm. The rib **502** also has a projected length **532** as measured along the origin y-axis. In certain embodiments, the projected y-axis length **532** is between about 9 mm and 12 mm. In one embodiment, the projected y-axis length **532** is about 10 mm to 11 mm.

The angle of return **526** of the rib **502** is important in preventing de-lamination or separation between the rear support member **546** and a face insert that is adhesively attached to the rear support member **546** and peripheral member **548**. In one embodiment, the angle of return **526** of the rib **502** is measured with respect to an origin X-Z plane **525**. In certain embodiments, the angle of return **526** between a top rib return surface **502***a* and the X-Z plane **525** is at least about 40 degrees. In some embodiments the angle of return **526** is between about 40 degrees and about 70 degrees. In one embodiment, the angle of return **526** is about 45 degrees. FIG. **5**C shows the X-Z plane **525** passing through a reference point **528** located at an edge or lip point at the end of the peripheral member **548** surface **548***a*.

The transition between the rib **502** and the crown interior surface **518** includes a radius transition **536** to reduce unwanted stress concentrations. In certain embodiments, the radius transition **536** is about 4 mm to about 12 mm, preferably 6 mm to about 10 mm, and more preferably about 8 mm. Again, the crown thickness **521** immediately after the radius transition **536** is at least about 1 mm to prevent crown **508** cracking.

FIG. **5**C further shows a transition crown thickness **542** in a region where the crown attaches and transitions to the undercut **540**. In one embodiment, the transition crown thickness **542** is between about 1 mm to about 2 mm. In one embodiment, the transition crown thickness **542** is about 1.4 mm.

The undercut spacing **550** defines the width of the undercut and a space between the crown interior surface **518** and the rear surface **548***b* of the peripheral member **548**. In some embodiments, the undercut spacing **550** is about 3 mm to about 4 mm or less than about 5 mm. In one embodiment, the undercut spacing **550** between the crown **508** and peripheral member **548** is about 3.6 mm.

FIG. **5**D illustrates a cross-sectional view of club head **500** taken along cross-sectional lines 5D-5D (also parallel with the origin Y-Z plane) in FIG. **5**A. The cross-sectional view of 5D-5D is taken through the rib **502** in addition to the crown **508** and insert support structure **547**. The rib **502** still includes an angle of return **526** with respect to a vertical plane or X-Z plane **525** as described above. The rib **502**, crown **508**, and insert support structure **547** are comprised of the same material, as shown.

FIG. **5**E illustrates a similar cross sectional view as FIG. **5**C including the face insert **551**, according to one embodiment. The face insert **551** includes a composite face **552** and a cover layer **554** which can be a metallic or polymer layer as previously described. In the embodiment shown in FIG. **5**E, the cover layer **554** can include a return side wall portion **558** disposed between the composite face **552** and the peripheral member **548**. An adhesive **556** is disposed between the face insert **551** and the face insert support structure **547**. A bond gap **557** is provided between the rear support member **546** and a rear surface of the composite face **552** where the adhesive material **556** fills the bond gap. In certain embodiments, the bond gap is less than about 0.8 mm or less than about 0.2 mm. In a preferred embodiment, the bond gap is about 0.15 mm or less.

As previously described, the angle of return **526** is at least about 40 degrees to prevent severe separation in the adhesive **556** located between the face insert **551** and rear support member **546**. In certain embodiments, the angle of return **526** and rib **502** are designed to withstand a high number of golf ball impacts on the club face.

Although the above descriptions focus on a single rib, it is understood that the features and dimensions described above are common to all three ribs **502**,**504**,**506** shown in FIG. **5**A.

FIG. **5**F illustrates another embodiment of a lower zone near the sole **560** having a face insert **551** including a composite face **552** and cover layer **554**. At least one lower undercut fill structure **566** or rib is provided and is attached to the sole **560** and rear support member **546** and peripheral member **548** as described previously. Furthermore, the lower rib structure **566** includes an angle of return **526** of at least 40 degrees from an X-Z plane as previously described.

In the exemplary embodiment of FIG. **5**F the cover layer **554** includes an outer edge **562** that is generally coplanar with the edge of the composite face **552**. In other words, the cover layer **554** does not include a return side wall portion. It is understood that more than one rib or undercut fill structure can be provided in the lower zone. In certain embodiments, up to three or more ribs can be provided in a location where golf off-center hits occur with the greatest frequency.

FIG. **5**G illustrates an alternative embodiment having similar features compared to the embodiment shown in FIG. **5**C. However, the embodiment of FIG. **5**G shows the first contact point **538** of the rib **502** being located away from the rear support member end or tip **544** and near a corner location connecting the rear support member **546** and peripheral member **548**. The first contact point **538** is located at a transition region between the rear support member **546** and the peripheral member **548**. The angle of return **526** is still about 45° or at least 40°. Because the rib **502** is providing less support to the rear surface member **546** in this embodiment, the deflection of the rear surface member **546** may be greater resulting in less durability than the embodiment shown in FIG. **5**C. In one example, the embodiment of FIG. **5**G is capable of withstanding 1,800 shots on the face of the club head.

The undercut fill structures described in FIG. **5**A-**5**G have the advantage of being lightweight and therefore avoid adding unnecessary weight to the front portion of the club head. Reducing the amount of unnecessary weight in the front portion of the club head ensures that a negative impact on club head CG and MOI is avoided.

In certain embodiments, the additional weight of three ribs is about 1.0 g to about 3.0 g total. In one specific example, the total additional weight of three ribs is about 1.7 g. The overall club head weight is about 200 g to about 210 g or less than about 250 g.

The club head of the embodiments described herein can have a mass of about 200 g to about 210 g or about 190 g to about 200 g. In certain embodiments, the mass of the club head is less than about 205 g. In one embodiment, the mass is at least about 190 g. Additional mass added by the undercut fill structures will have a limited effect on moment of inertia and center of gravity values as shown in Tables 1 and 2. Table 1 illustrates exemplary MOI that can be achieved by the embodiments described herein.

TABLE 1

I_{xx} (kg · mm^2)	I_{yy} (kg · mm^2)	I_{zz} (kg · mm^2)
380 to 390	320 to 330	550 to 560
370 to 400	310 to 340	540 to 570
360 to 410	300 to 350	530 to 580

The embodiments described conform with the U.S.G.A. Rules of Golf and in some examples the I_{zz} is less than 590 kg·mm^2 plus a test tolerance of 10 kg·mm^2.

Table 2 illustrates exemplary CG location coordinates with respect to the origin point axes.

TABLE 2

CGX origin x-axis coordinate (mm)	CGY origin y-axis coordinate (mm)	CGZ origin z-axis coordinate (mm)
3 to 4	38 to 39	−5 to −6
2 to 5	37 to 40	−4 to −7
1 to 6	36 to 41	−3 to −8

Again, the undercut fill structures described herein are lightweight enough so that a negative impact on CG location is avoided. In certain embodiments, the CG x-axis coordinate is between approximately −5 mm and approximately 10 mm, a CG y-axis coordinate is between approximately 20 mm and approximately 50 mm, and a CG z-axis coordinate between approximately −10 mm and approximately 5 mm.

FIG. **6** illustrates another embodiment of a club head **600** having a crown portion **604**, a toe portion **608**, a heel portion **612**, a front portion **610**, a hosel **606**, and a undercut fill structure **602** located in the front portion **610** of the club head.

FIG. **7** illustrates a cross-sectional view of another exemplary embodiment of a club head **700** taken along cross-sectional lines **7-7** (parallel with the Y-Z plane) in FIG. **6**. The club head **700** includes a crown portion **720**, an interior crown surface **722**, an undercut fill structure **702**, a return surface **702*a***, a first contact point **708**, a second contact point **710**, an edge reference point **712**, an angle of return **704**, a face insert support structure **714**, a rear support member **716**, a peripheral member **718**, and a recess or undercut **706**, as similarly described above. In one embodiment, the undercut fill structure **702** can include a blending radius **721** into the interior crown surface **722**. It is understood that a blending radius **721** can be excluded in other embodiments.

However, in one embodiment, the undercut fill structure **702** is not a metallic material but is comprised of an epoxy adhesive such as 3M™ Scotch-Weld™ Epoxy Adhesive DP460 is utilized having a shore D hardness of about 75 to 84, as previously mentioned. The undercut fill structure return surface **702*a*** is substantially planar and can be easily used to calculate the angle of return **704**. It is understood that materials with properties similar to DP460 can be used such as polycarbonate (i.e. injection mold grade Lexan®, ABS (i.e. injection mold grade Cycolac G121), nylon 6 and 6/6, and other general purpose and engineered polymers. A material having a density of about 0.25 g/cm^3 to about 2 g/cm^3 (or about 1.2 g/cm^3) a modulus of elasticity of about 306 ksi, tensile strength of about 7,000 psi, an elongation of about 8% and a Tg of about 56° C. can be used.

Some examples of materials that can be used as a undercut fill structure, without limitation include: polycarbonate; polycarbonate resin thermoplastic; viscoelastic elastomers; vinyl copolymers with or without inorganic fillers; polyvinyl acetate with or without mineral fillers such as barium sulfate; acrylics; polyesters; polyurethanes; polyethers; polyamides; polybutadienes; polystyrenes; polyisoprenes; polyethylenes; polyolefins; styrene/isoprene block copolymers; metallized polyesters; metallized acrylics; epoxies; epoxy and graphite composites; natural and synthetic rubbers; piezoelectric ceramics; thermoset and thermoplastic rubbers; foamed polymers; ionomers; low-density fiber glass; bitumen; silicone; and mixtures thereof. The metallized polyesters and acrylics can comprise aluminum as the metal. Commercially available materials include resilient polymeric materials such as Scotchdamp™ from 3M™, Sorbothane® from Sorbothane, Inc., DYAD® and GP® from Soundcoat Company Inc., Dynamat® from Dynamat Control of North America, Inc., NoViFlex™ Sylomer® from Pole Star Maritime Group, LLC, Isoplast® from The Dow Chemical Company, and Legetolex™ from Piqua Technologies, Inc. In one embodiment the reinforcement material may have a modulus of elasticity ranging from about 0.145 ksi to about 3,625 ksi, and a durometer ranging from about 5 to about 95 on a Shore D scale. In one embodiment, the undercut fill material is an epoxy adhesive having a cured Shore D hardness value of about 75-80. In other examples, gels or liquids can be used, and softer materials which are better characterized on a Shore A or other scale can be used. The Shore D hardness on a polymer is measured in accordance with the ASTM (American Society for Testing and Materials) test D2240.

As seen in FIG. **6**, the undercut fill structure or material **602** fills a specific region in the gap or undercut region between the crown portion and the face insert support structure. Instead of individual structures, the undercut fill structure or material **602** is a single integral undercut fill structure. Although, it is possible to create multiple separate and non-integral undercut fill structures with the materials described above.

FIG. **8** illustrates a cross-sectional view of another exemplary embodiment of a club head **800** taken along cross-sectional lines **8-8** (parallel with the origin Y-Z plane) in FIG. **6**. The club head **800** includes a crown portion **820**, an interior crown surface **822**, a undercut fill structure **802**, a return surface **802*a***, a first contact point **808**, a second contact point **810**, an edge reference point **812**, an angle of return **804**, a face insert support structure **814**, a rear support member **816**, a peripheral member **818**, and a recess or undercut **806**, as similarly described in FIG. **7**.

However, FIG. **8** illustrates a return surface **802*a*** of the undercut fill structure **802** that is non-linear in the cross-sectional view. In other words, the return surface **802*a*** is generally non-planar across the return surface. In such instances, it may be initially difficult to determine a return angle **804**. One method to determine a return angle **804** is to determine a linear trend line **824** at a given cross-section through the undercut fill structure **802**. The trend line **824** can be determined by initially plotting the surface variation between the first contact point **808** and the second contact point **810**. After the non-linear surface points are determined, a linear regression or trend line **824** is calculated using the least squares function.

Thus, the final trend line **824** is utilized to determine an effective angle of return **804** that is within the ranges described herein. It should be noted that the final trend line **824** does not necessarily pass through the first contact point **808** and second contact point **810**.

FIG. **9** illustrates an exemplary club head **900** in a rotated side view from which two exemplary embodiments are described.

FIG. **10** illustrates a cross-sectional view of another exemplary embodiment of a club head **1000** taken along cross-sectional lines **10-10** in FIG. **9**. The club head **1000** includes a hosel **1016**, a recess or undercut **1020**, a crown portion **1022**, and a face insert support structure **1014**. The club head **1000** is similar to the embodiment described in FIGS. **5**A-**5**E.

The club head **1000** further includes three rib structures **1008**,**1010**,**1012** or ribs located in an upper striking zone region between the crown portion **1022** and the face insert support structure **1014** as described at least in FIG. **5**C. The heel rib **1008**, center rib **1010**, and toe rib **1012** are located in an upper zone. More specifically, the three ribs **1008**,**1010**, **1012** are spaced apart according to an overall width dimension **1002** as measured parallel to the origin point X-axis. The overall width dimension **1002** is measured from the centerline axis of the toe-side rib **1012** to a centerline axis of the heel-side rib **1008**. In certain embodiments, the overall width dimension **1002** is about 70 mm or less. In one embodiment, the width dimension **1002** is between about 10 mm to 70 mm as measured along the origin point X-axis. In another embodiment, the overall width dimension **1002** is about 40 mm or less. In yet another embodiment, the width dimension **1002** is about 20 mm to about 60 mm. In order to reduce unwanted mass, the width dimension **1002** can be about 30 mm. The midpoint of the overall width dimension **1002** is centered about the origin point where the X-axis location is about zero. The center rib **1010** is located near the midpoint of the overall width dimension **1002**. Therefore, for example, a total width dimension **1002** of about 60 mm indicates that the rib structures occupy a zone extending about 30 mm in a positive X-direction and about 30 mm in a negative X-direction within an upper zone of the club head **1000**.

In one embodiment, each individual rib **1008**,**1010**,**1012** has a first width dimension **1006** and a second width dimension **1004** as measured along the origin X-axis. The first width dimension **1006** is the width of the individual rib **1008**,**1010**, **1012** near a first contact point where the rib **1008**,**1010**,**1012** end is attached to the face insert support structure **1014** (i.e. the tip of the rear support member). In certain embodiments, the first width dimension **1006** is about 1 mm to about 3 mm or less than about 5 mm. In one embodiment, the first width dimension **1006** is between about 1 mm and 2 mm.

The second width dimension **1004** is the width of the individual rib **1008**,**1010**,**1012** near a second contact point where the rib **1008**,**1010**,**1012** end is attached to the interior crown surface **1024**. In certain embodiments, the second width dimension **1004** is about 5 mm to about 15 mm or less than 20 mm. In one embodiment, the second width dimension **1004** is about 10 mm to about 15 mm, or about 11 mm. The second width dimension **1004** being greater than the first width dimension **1006** ensures that any force transferred through the rib to the interior crown surface **1024** is distributed to the crown portion **1022** over a larger and wider surface area. Therefore, a transfer force from the rib **1008**,**1010**,**1012** to the crown portion **1022** is more evenly distributed and a highly localized transfer force that is likely to cause damage to the crown portion **1022** is avoided.

In addition, each rib **1008**,**1010**,**1012** is spaced apart from each other by a spacing distance **1018**. Depending on the number of ribs **1008**,**1010**,**1012** provided, the spacing distance **1018** can vary between about 5 mm and about 70 mm. In the embodiment having three distinct ribs, the spacing distance **1018** is about 25 mm to about 35 mm or less than 35 mm. In one embodiment, the spacing distance **1018** is about 30 mm.

FIG. **11** illustrates a cross-sectional view of another exemplary embodiment of a club head **1100** taken along cross-sectional lines **11-11** in FIG. **9**. The club head **1100** includes a hosel **1108**, a crown portion **1110**, a crown interior surface **1112**, an undercut or recess **1114**, a face insert support structure **1106** and a undercut fill structure **1102**. The embodiment shown is similar to the embodiment described in FIGS. **6** and **7**.

The undercut fill structure **1102** is an adhesive material as previously described and is a single integrated piece. The undercut fill structure **1102** includes a first width dimension **1104** near the attachment of the undercut fill structure **1102** to the tip of the rear support member of the face insert support structure **1106**. The undercut fill structure **1102** also includes a second width dimension **1116** near the attachment of the undercut fill structure **1102** to the interior crown surface **1112**. The first width dimension **1104** and second width dimension **1116** are measured along the origin point X-axis as described above. In certain embodiments, the second width dimension **116** is wider than the first width dimension **1104** to achieve lower stress concentrations on the crown portion **1110**. In another embodiment, the first width dimension **1104** is about the same as the second width dimension **116** for weight savings.

The undercut fill structure **1102** includes a first edge **1102***a* and a second edge **1102***b*. The first edge **1102***a* conforms to and follows a rear support member end or tip **1118** contour. The second edge **1102***b* conforms to and follows the interior crown surface **1112** contour to while maintaining a relatively flat undercut fill structure surface **1102***c*. The undercut fill structure surface **1102***c* forms an angle of return with a vertical X-Z plane as previously described. It should be noted, in one embodiment, that the undercut fill structure **1102** does not contact a face insert that is placed in the front opening. The undercut fill structure **1102** is placed inside the club head prior to the attachment of the face insert and cured at a certain temperature.

In certain embodiments where the undercut fill structure is an epoxy adhesive, the overall weight of the undercut fill structures remains light to prevent negative impacts on the CG location and MOI. For example, according to certain exemplary embodiments, the undercut fill structure is a single adhesive structure weighing about 5 g or less. In one embodiment, the undercut fill structure weights about 4 g. In other embodiments, the overall additional weight of the undercut fill structure is less than 10 g total.

EXAMPLES

Table 3 below provides various club head embodiments having specific features and undercut fill structure configurations as discussed above. The "Undercut Fill Description" describes the type of undercut fill structure such as the type of fill material or number of ribs. The "Fill Material Width" is the width dimension described above in a direction parallel with the origin point x-axis. The "Width Between the Outermost Ribs" is the distance between the heel-most and toe-most rib centerlines. The "No. of Impact/Shots Before Failure" is the number of shots on the club face before mechanical failure occurs.

TABLE 3

Example No.	Undercut Fill Description	Fill Material Width (mm)	Width Between Outermost Ribs (mm)	Angle of Return	No. of Impacts/Shots Before Failure
1	Epoxy Adhesive (DP460 ®)	60	—	45°	6000

TABLE 3-continued

Example No.	Undercut Fill Description	Fill Material Width (mm)	Width Between Outermost Ribs (mm)	Angle of Return	No. of Impacts/Shots Before Failure
2	Acrylics	60	—	45°	3300
3	Epoxy Adhesive (DP460 ®)	60	—	~5°-10°	1600
4	Epoxy Adhesive (DP460 ®)	60	—	~25°-35°	2100
5	Polycarbonate	60	—	45°	6000
6	Three Ribs	—	60	45°	3500

As the test results in Table 3 show, examples 1 and 2 having a fill material at an angle of return of about 45° withstand a high number of impacts or shots without mechanical failure. However, example 3 includes an angle of return of about 5°-10° and fails to achieve a durability standard of withstanding a high number of shots. Similarly, example 4 includes an angle of return of about 25°-35° and also fails to withstand a high number of shots. Example 5 includes a polycarbonate fill material, such as Lexan®, which is also has a 45° angle of return and therefore has a higher durability value. Example 6 includes a three rib design as previously described in at least FIG. **5**C (instead of the fill material) having a 45° angle of return and therefore also withstands a high number of shots on the face of the club.

One advantage of the present invention is that an undercut fill structure is provided that does not add a significant amount of weight to the front portion of the golf club head. Excessive undercut fill structure weight can negatively impact the CG location, moment of inertia, and overall club head weight. Thus, the undercut fill structures described herein are lightweight.

In addition, the undercut fill structures described herein prevent unwanted stress concentrations to the crown, sole, or body of the club head. Therefore, large transfer forces through the undercut fill structures are less likely to cause mechanical failure.

Another advantage of the present invention is that a relatively high coefficient of restitution (COR) can be maintained. The COR measured in accordance with the U.S.G.A. Rule 4-1a is greater than 0.810 in the embodiments described herein. In addition, a consistent characteristic time (CT) of less than 239 μs with a maximum test tolerance of 18 μs is met by the embodiments described herein. In certain embodiments, the CT is less than at least 257 μs as measured in accordance with the USGA "Procedure for Measuring the Flexibility of a Golf Clubhead", Revision 2.0, Mar. 25, 2005.

In view of the many possible embodiments to which the principles of the disclosed invention may be applied, it should be recognized that the illustrated embodiments are only preferred examples of the invention and should not be taken as limiting the scope of the invention. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of the invention as set forth. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

We claim:

1. A golf club head comprising:

a hollow club head body having an external surface with a heel portion, a toe portion, a crown portion, a sole portion, an interior cavity, and a front opening, wherein the front opening opens to the interior cavity;

a face insert support structure located at the front opening, the support structure including a peripheral member and a rear support member, the rear support member having a front surface and a rear surface;

a face insert attached at the front opening and closing the front opening of the body;

at least two undercut fill structures attached to a portion of the rear surface of the rear support member;

wherein the at least two undercut fill structures each form a return angle with respect to a vertical x-z plane and are attached to one of the crown portion and sole portion;

wherein the front opening defines an aperture to an interior.

2. The golf club head of claim **1**, wherein the face insert includes at least a portion comprising prepreg plies having a fiber areal weight.

3. The golf club head of claim **2**, further comprising a metallic cap attached to the prepreg plies wherein the prepreg plies are configured to reinforce a majority of a metallic cap striking surface, the metallic cap abutting the transition edge to form a substantially flush golf club head front surface.

4. The golf club head of claim **3**, wherein the thickness of the prepreg plies is about 4.5 mm or less, and the thickness of the metallic cap is about 0.5 mm or less, and wherein the golf club head has a coefficient of restitution of at least 0.79 and a characteristic time of less than at least 257 μs.

5. The golf club head of claim **3**, wherein the metallic cap is comprised of a titanium alloy.

6. The golf club head of claim **2**, wherein the prepreg plies include carbon fiber reinforcement having a fiber areal weight of at least 100 g/m^2, the face insert's total thickness is within a range of about 2.5 mm to about 4.5 mm.

7. The golf club head of claim **2**, wherein the prepreg plies have a fiber areal weight of less than 100 g/m^2.

8. The golf club head of claim **1**, wherein the face insert's total thickness is within a range of about 1 mm to about 8 mm.

9. The golf club head of claim **1**, wherein the thickness of the face insert is non-constant.

10. The golf club head of claim **1**, wherein the peripheral member extends around at least a portion of a periphery of the front opening, and wherein the face insert is coupled to the peripheral member.

11. The golf club head of claim **1**, wherein the at least two undercut fill structures each substantially attaches to a tip portion of the rear support member.

12. The golf club head of claim **1**, wherein a front region of the crown is at least about 1 mm thick in a location where the at least two undercut fill structures attach to an interior surface of the crown.

13. The golf club head of claim **1**, wherein the at least two undercut fill structures each include at least three ribs spaced from one another.

14. The golf club head of claim **1**, wherein the at least two undercut fill structures include a transition radius between each undercut fill structure and at least one of the crown portion and the sole portion.

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